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Acute renal failure requiring renal replacement therapy: incidence and outcome

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Summary

Background: Renal replacement therapy (RRT) for acute renal failure (ARF) may be provided in many settings within the hospital. Such patients require a high level of care and often have a poor prognosis. No prospective studies have accurately defined this population, making the prediction of necessary resources and the planning of services difficult.
Aim: To ascertain the incidence, causes and outcomes of acute renal failure requiring renal replacement therapy in Scotland.
Design: A prospective observational census of all clinical areas providing renal replacement therapy in three Scottish health boards (Grampian, Highland, Tayside).
Methods: Patients were identified by liaison with each unit providing RRT. Factors precipitating renal failure and reasons for RRT were recorded at the time of initiation. Comorbid disease burden was scored using the Charlson index. Patient status at 90 days was assessed from case-notes, contacting general practitioners where necessary.
Results: 375 patients per million population per year received RRT; 203 per million per year for either ARF or acute-on-chronic renal failure. 73.5% of patients receiving RRT for ARF died within 90 days, 23.5% became independent of RRT. The median duration of hospital admission was 19 days.
Discussion: The annual incidence of ARF requiring RRT is just over 200 per million population, almost twice that of end-stage renal disease requiring RRT. Such treatment places high demands upon health care resources.

Introduction

Acute renal failure (ARF) is defined as a sudden, sustained decline in glomerular filtration rate, usually associated with uraemia and a fall in urine output.[1] Most patients with ARF do not require renal replacement therapy (RRT). The decision to start RRT is made on an individual basis when a number of physiological parameters are considered in association with each other, and therefore is instituted at differing levels of glomerular filtration rate, uraemia and urine output.

The prior renal function of many patients who present with apparent ARF is not known, therefore the duration of impairment of their renal function is uncertain. Patients with a degree of pre-existing chronic renal failure (CRF) may suffer an intercurrent illness causing a sudden deterioration in their renal function, the reversibility of which may not be predictable, the so-called acute-on-chronic renal failure (ACRF).

The treatment of ARF may be conducted in renal units, intensive care units (ICUs) and occasionally other high-dependency areas. Whilst RRT is often provided under the auspices of a nephrologist, continuous treatments may be provided in the ICU

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Table 1 Mode of presentation for RRT

Mode of presentation	Inclusion criteria
Acute renal failure	Presented unexpectedly with normal sized kidneys, *or* presented after known renal insult, previous renal function normal, *or* presented after known renal insult, previous function unknown but normal size kidneys
Acute-on-chronic	Presented either unexpectedly or after a known renal insult *and* known to have had previous serum creatinine >150 μmol/l, *or* shown on ultrasound to have at least one small kidney (<8 cm)
Chronic renal failure	Known to have had chronic renal failure followed by a physician, no obvious renal insult precipitating requirement for dialysis

or high-dependency unit by intensivists, without referral to nephrology services.

Accurate study of the incidence and outcomes of ARF requiring RRT in all of its guises is difficult, particularly the identification of all relevant patients. Predicting the level of resources required to provide RRT for ARF, and the provision of longer-term care for such patients, is also difficult. There have been no prospective population studies in the UK that have addressed the incidence and outcomes of ARF simultaneously in all hospital locations where such treatment takes place.

Retrospective community based studies of biochemistry laboratory results report the annual incidence of ARF (creatinine ⩾300 μmol/l) to be 620 per million population (pmp), and that of advanced ARF (creatinine ⩾500 μmol/l) to be between 102 and 140 pmp.[2,3] These retrospective studies report that 50 patients pmp with creatinine ⩾300 μmol/l and 22 patients pmp with creatinine ⩾500 μmol/l received RRT for ARF each year. Patients with underlying renal failure and those who failed to recover were excluded from study, as were those who received RRT with serum creatinine levels below the threshold chosen for inclusion. More recently, a prospective study of ARF in hospital in-patients in East Kent, defining ARF as creatinine ⩾300 μmol/l or urea >40 μmol/l, found an incidence of ARF of 486 pmp/year.[4] A Spanish study of ARF (defined as creatinine ⩾177 μmol/l) among all adult admissions to 13 tertiary-care hospitals within the Madrid area, found an incidence of 209 cases pmp, RRT being required in 36%.[5]

The aim of this study was to identify prospectively all patients from a known population receiving RRT for ARF, irrespective of biochemical parameters and location of treatment, and to assess the causative factors of their ARF and its outcome.

Methods

Over an eleven-week period commencing 1/5/2000, all adult patients receiving RRT for the first time for ARF or CRF in each of the Grampian, Highland and Tayside health board areas were prospectively studied and their status 90 days after the start of treatment was recorded. Each of these health boards has only one hospital providing RRT, but treatment was provided in intensive care units (ICU) and coronary care units (CCU) as well as within dedicated renal units. Aberdeen Royal Infirmary has a cardiothoracic unit, intensive care for these patients being provided in the main hospital ICU, therefore our study is representative of areas in which such high-risk treatment is delivered.

Patients were identified by contacting a liaison person in each unit providing RRT in each hospital, at least weekly. All data were collected from case notes, and where available computer systems, by a single observer and entered onto the Scottish Renal Registry. No distinction was made between intermittent haemodialysis and continuous haemofiltration, and the duration of treatment was counted in days from the date of the first episode of RRT to the last.

Patients were prospectively entered into three groups according to their mode of presentation for RRT (Table 1). Up to three factors precipitating renal failure in the ARF and ACRF groups were coded at the time of initiation of RRT, and up to three reasons for the initiation of RRT were recorded.

The comorbid disease burden of each patient was scored using the Charlson index of comorbidity, excluding the additional weighting for patient age (Table 2).[6]

Serum biochemistry and haematology, as well as blood pressure, urine output, the use of antibiotics and inotropic medication, were recorded for each patient immediately prior their first RRT treatment. The duration of each patient's stay in hospital, to the nearest day, was also recorded.

The status of each patient after 90 days was assessed from hospital case-notes and by contacting general practitioners when necessary.

Table 2 Charlson comorbidity index

Weight	Conditions
1	Myocardial infarct; CCF; PVD; cerebrovascular disease; dementia; chronic pulmonary disease; connective tissue disease; peptic ulcer disease; mild liver disease; diabetes
2	Hemiplegia; moderate or severe renal disease; diabetes with end organ damage; any tumour (solid tumour without metastasis, diagnosed in past 5 years); leukaemia (acute and chronic, and polycythemia vera); lymphoma (incl. Hodgkin's, Waldenstrom's, myeloma, lymphosarcoma)
3	Moderate or severe liver disease (cirrhosis, portal hypertension, varices)
6	Metastatic solid tumour; HIV

Statistical analysis

For univariate analyses, χ^2, Kruskal Wallis or t-tests were used where appropriate. Confidence intervals for incidences were calculated using the standard error of proportions. A 5% significance level was used throughout. All statistical analyses were performed using SPSS for Windows, v. 9.0.

Results

Over the eleven-week study period, 89 patients (58 males, 65%) started RRT for renal failure of all types in the health board areas of interest. The combined estimated population (mid-1999) of the areas studied is 1 122 200 people (Grampian 525 300; Highland 208 600; Tayside 388 300).[7] This equates to an incidence of 375 pmp/year receiving RRT. Of these 89, 37 (156 pmp) started RRT in a planned manner for ESRD. Four patients treated for ARF lived outside the health board areas studied. Therefore 48 patients with home address within the health board areas studied were treated for either ARF or ACRF during the study period (203 pmp/year) (Table 3).

Each patient had up to three insults precipitating ARF recorded. The most common precipitating factor was sepsis, at least partly causative in 69% of cases. Some 25% of cases occurred following surgery, 13.5% were at least partly due to either obstruction of the urinary tract or hypotension, hypovolaemia contributed to 9.6%, pancreatitis or administration of a nephrotoxic agent to 6%, and gastrointestinal haemorrhage to 4%. Less common factors were myeloma, rhabdomyolysis, hepatorenal syndrome, non-gastrointestinal haemorrhage, myocardial infarction and primary renal disease.

Table 3 Presentation for RRT

	n	Incidence (pmp/year)*	95%CI
Acute	31	131	108–153
Acute-on-chronic	17	72	55–89
Chronic	37	156	131–181
Total	85	358	320–396

*Using the estimated population on 30/6/1999 from the Registrar General for Scotland (excluding patients not domiciled within study area).

Up to three reasons for the initiation of RRT were recorded for each patient. The most common reason was elevated urea and creatinine, but treatment was primarily initiated because of hyperkalaemia, acidosis or fluid overload in 48% of patients. RRT was started in the ICU for 29 (56%) patients, in a CCU for one patient, and in a renal unit for the remainder.

When the groups of patients with ARF and ACRF were compared, those with ARF were younger (median age 65.8 years vs. 74.9 years). Those with ARF were more likely to have treatment initiated in ICU and to be treated with inotropic drugs at the time of starting RRT. They also had higher haemoglobin concentrations, median 10.4 g/dl vs. 8.4 g/dl ($p = 0.02$, χ^2). The ACRF group had a greater burden of underlying comorbid illness as assessed by the Charlson score (Table 4).

There was no statistically significant difference in potassium, bicarbonate, creatinine, albumin, white blood cell count, platelet count nor systolic or diastolic blood pressure prior to starting RRT between the ARF and ACRF groups.

All patients were followed-up for 90 days. Some 73.5% of ARF patients died during follow-up (23.5% within 48 h), 23.5% recovered sufficient renal function to be independent of RRT and one remained alive but dialysis-dependent (Table 5). The mortality of patients with ARF who started RRT in the ICU was 83%; that among those starting on the renal unit was 55%. Some 67% of patients with ACRF died during follow-up; 16.5% recovered renal function.

The 11 patients presenting with ARF or ACRF who recovered independent renal function had a median duration of RRT of 3 days (IQR 2–11, range 1–19). The 37 patients who died also had a median duration of RRT of 3 days (IQR 1–9.5, range 1–32); their median survival from the time of starting RRT was 8 days (IQR 3.5–27, range 1–68).

Table 4 Patient characteristics

	Acute ($n = 34$)	Acute on chronic ($n = 17$)	All patients	p
Median age (range)	65.8 (23–90.6)	74.9 (55.6–86.3)	71.4 (IQR 56.4–77.2)	0.006*
Median Charlson score (range; IQR)	2 (0–6; 0–3)	3 (0–9; 2–3.5)	2 (IQR 1–3)	0.005*
RRT initiated in ICU	23 (67.6%)	6 (33.3%)	29 (55.8%)	0.04 χ^2
Inotropes used	25 (73.5%)	5 (35.3%)	30 (57.7%)	0.006 χ^2
Median serum creatinine (range)	314 (64–1676)	521 (304–678)	411 (IQR 280–603)	NS

*Mann-Whitney U test.

Table 5 Patient outcomes at 90 days

Status by 90 days	Acute	Acute on chronic	Chronic	All patients
Recovered	8 (23.5%)	3 (16.5%)	–	11 (12%)
On haemodialysis	1 (3%)	3 (16.5%)	19 (51%)	23 (26%)
On peritoneal dialysis	–	–	14 (38%)	14 (16%)
Dead	25 (73.5%)	12 (67%)	4 (11%)	41 (46%)

The median duration of hospital admission those presenting with ARF or ACRF was 19 days (IQR 11–41, range 1–90). Four patients were still in hospital at the end of the 90-day follow-up period.

Discussion

This prospective study of a known population found ARF requiring RRT occurred at an incidence of around 200 pmp/year; at least a third of these cases occurring in patients with a degree of pre-existing CRF. The study was of relatively short duration, and therefore can take no account of any seasonal variation.

This incidence is higher than that reported by retrospective UK community studies[2,3] or the prospective study of acute admissions to Madrid hospitals.[5] The apparent increase in incidence is partly due to differing inclusion criteria, as we have prospectively included all patients receiving RRT, irrespective of their serum biochemistry, diagnosis or eventual outcome. A prospective study of dialysis for ARF (defined as RRT of <90 days duration) in Dumfries, reported a very similar incidence of 196 patient episodes pmp/year.[8] The apparent increase in the incidence of ARF treated by RRT, is also in part due to more elderly patients and those with comorbid illnesses undergoing operative interventions (particularly vascular surgery), but also to increased referral for, and provision of, RRT for ARF.[9] Comorbidity was common in the group of patients we studied, as demonstrated by Charlson scores, and the median age of patients when starting RRT was 71.4 years. It seems likely that older patients with greater comorbidity are being offered treatment that previously would not have been available to them.

The survival of patients with ARF requiring RRT was poor; 71% of patients with ARF and ACRF died within 90 days of starting RRT, and their median survival was only 8 days. Those treated (at least initially) in the ICU had a worse prognosis, with a 90-day mortality of 83%. ARF treated in the ICU is relatively well-described, with mortality reported at between 64–79%.[10–13]

The ACRF group were older with more comorbid disease when compared with the ARF group, but this was not reflected in a higher mortality, perhaps because a lesser pathological insult was required to necessitate RRT in this group.

Some 8% of patients with ARF and ACRF still required RRT after the completion of 90 days of treatment. While recovery may still take place beyond this point, a proportion of such patients go on to require long-term RRT. In a study of patients with both respiratory and renal failure treated in Scottish ICUs, 3.5% of patients required long-term RRT.[13] In a series of 1095 patients with ARF (defined as serum creatinine $\geqslant 600$ μmol/l and/or requiring RRT) who were treated by a single renal unit, 16% required long-term RRT and comprised 18.4% of patients entering that centre's long-term dialysis programme.[14] In a prospective population study of patients starting RRT for end-stage renal disease in Scotland, 10.7% of such patients had unrecovered ARF and 11.8% unrecovered ACRF.[15]

This study was of a relatively small population. There is a need for a prospective national study which, having here established and piloted the methodology, we hope to undertake. We have, however, demonstrated with this study that the incidence of ARF requiring RRT is greater than that of end stage renal disease (ESRD). The provision of renal services and dialysis facilities, in particular, often focuses upon the ever-increasing numbers of patients being treated long term for ESRD. The treatment of ARF with RRT requires a high intensity of care and places large demands upon renal services, therefore an accurate understanding of the incidence, outcomes and resources required is imperative if such services are to meet demand efficiently, and provide a high standard of care.

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